Evaluation of the impact of top-off on the ALS users

July 27 2004

David Robin, Christoph Steier, and Tony Warwick

Motivation

Motivation

- Identify issues and mitigate potential problems with top-off
  - Evaluate the impact of the present injection process on various types of user experiments
- Help define the scope of the project

Process

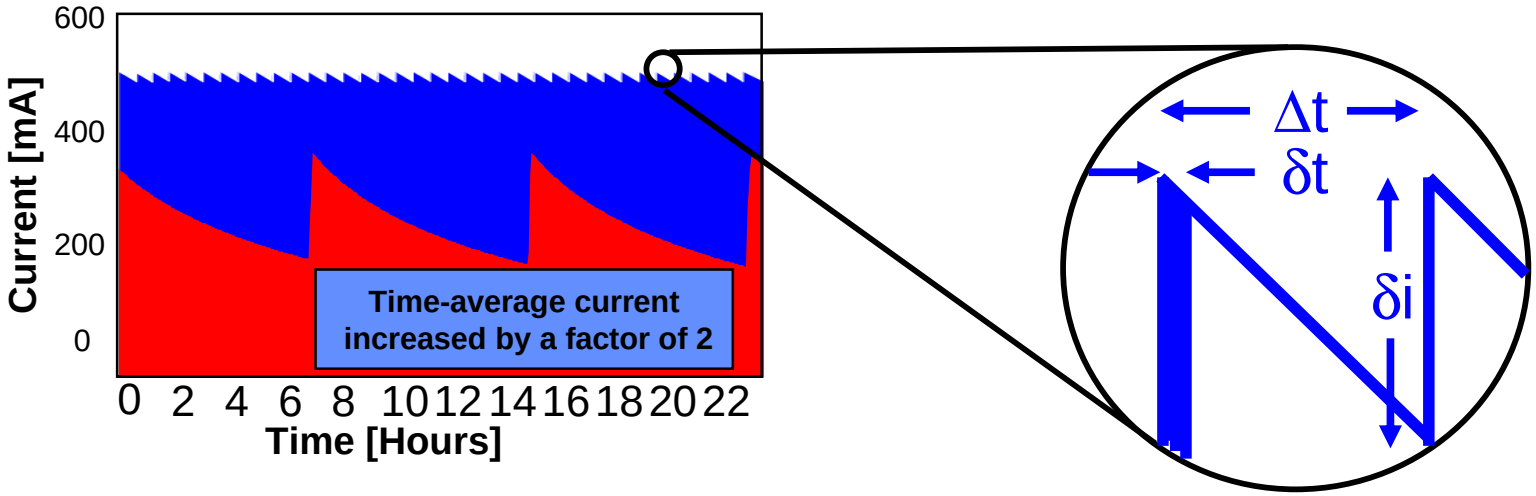
- Experiments with representative user groups
- Discussion of experimental results and top-off parameters in meetings with experiment participants and with the UEC

Issues that were addressed

- Allowable change in current when topping up
- Allowable orbit disturbance during injection
  - Amount and duration
  - Is gating an option?
- Inject equally spaced in time or current drop
  - Inject one pulse or several pulses (burst mode)
- Two bunch mode and camshaft beam cleaning

Injection Tests for Top Off

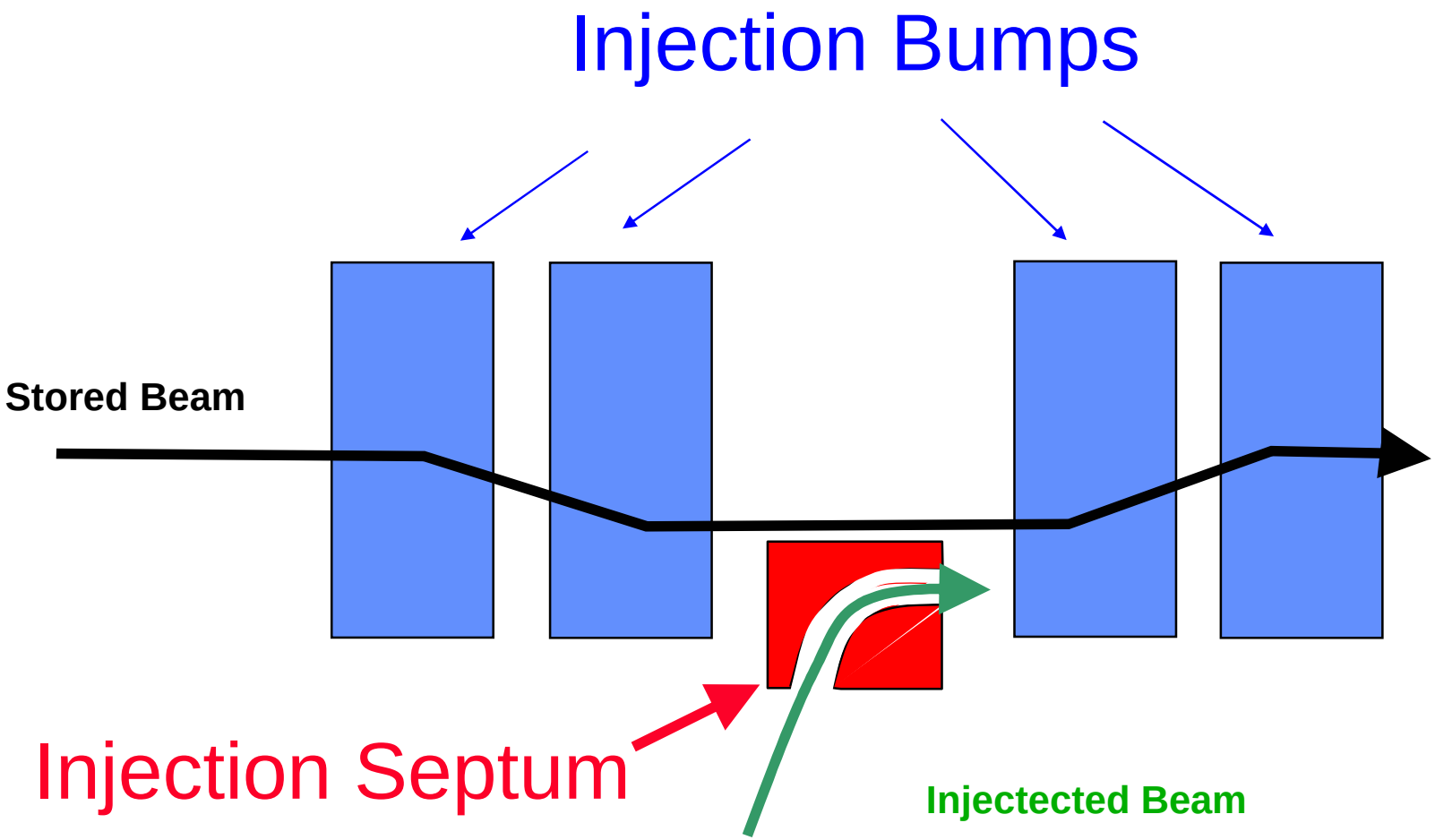
This note records effects observed at various beam lines during injection tests to simulate the closed orbit perturbations expected when the ALS operates in top-off mode. Injection is planned at 1.9GeV with the shutters open, to maintain the current at 500mA.



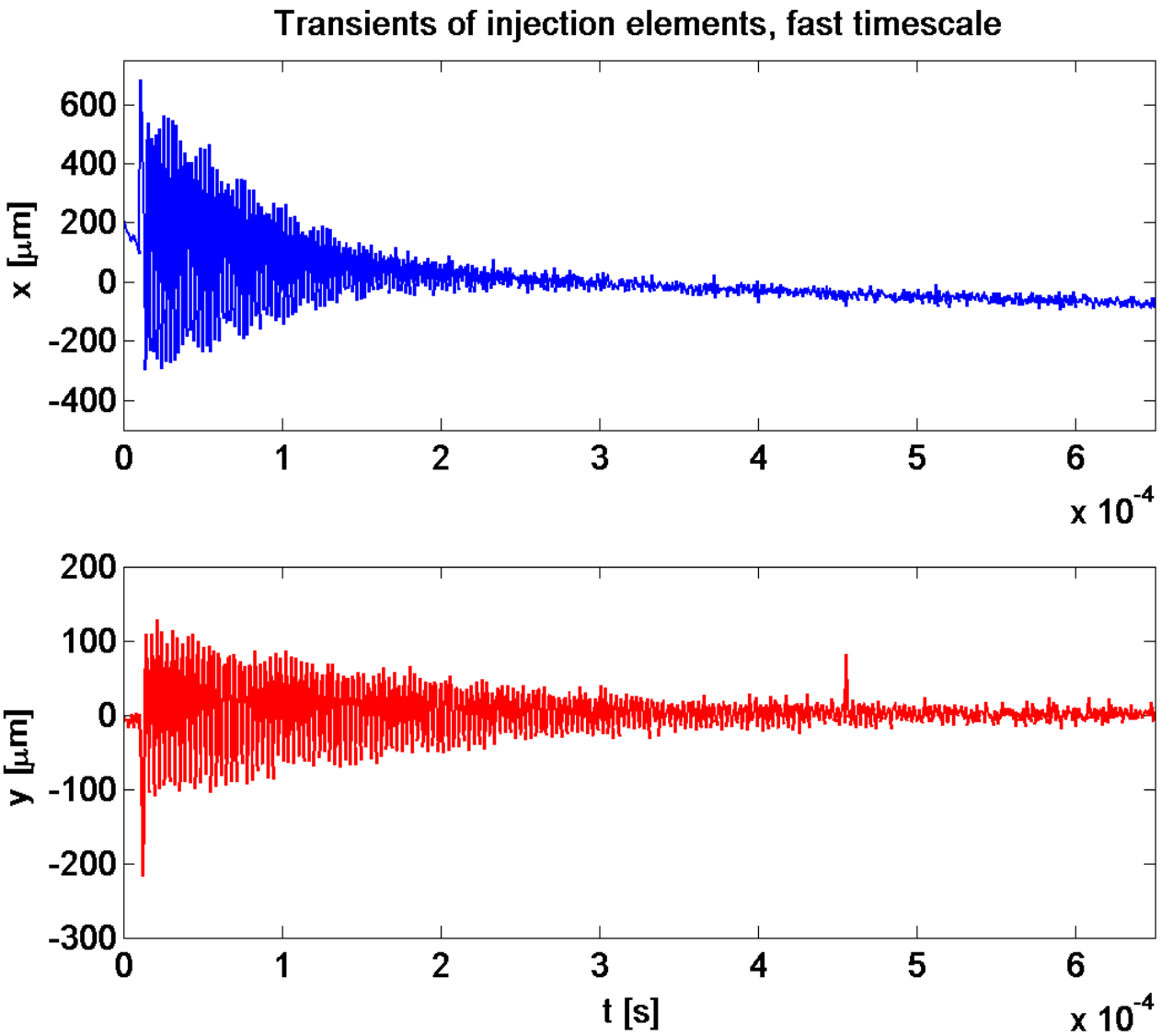
coupling	δi	Δt	δt	ε_v	σ_h	σ_v	σ'_h	σ'_v
Operational 03	1.5mA	72.0s	≤50ms	150×10^{-12}	298μm	23μm	22μrad	6μrad
Intermediate	1.5mA	32.0s	≤50ms	30×10^{-12}	298μm	8μm	22μrad	3μrad
Smallest Ever	1.5mA	14.4s	≤50ms	5×10^{-12}	298μm	3μm	22μrad	1μrad

Injection Elements

Injection Elements in Straight 1



Effect of the Bumps

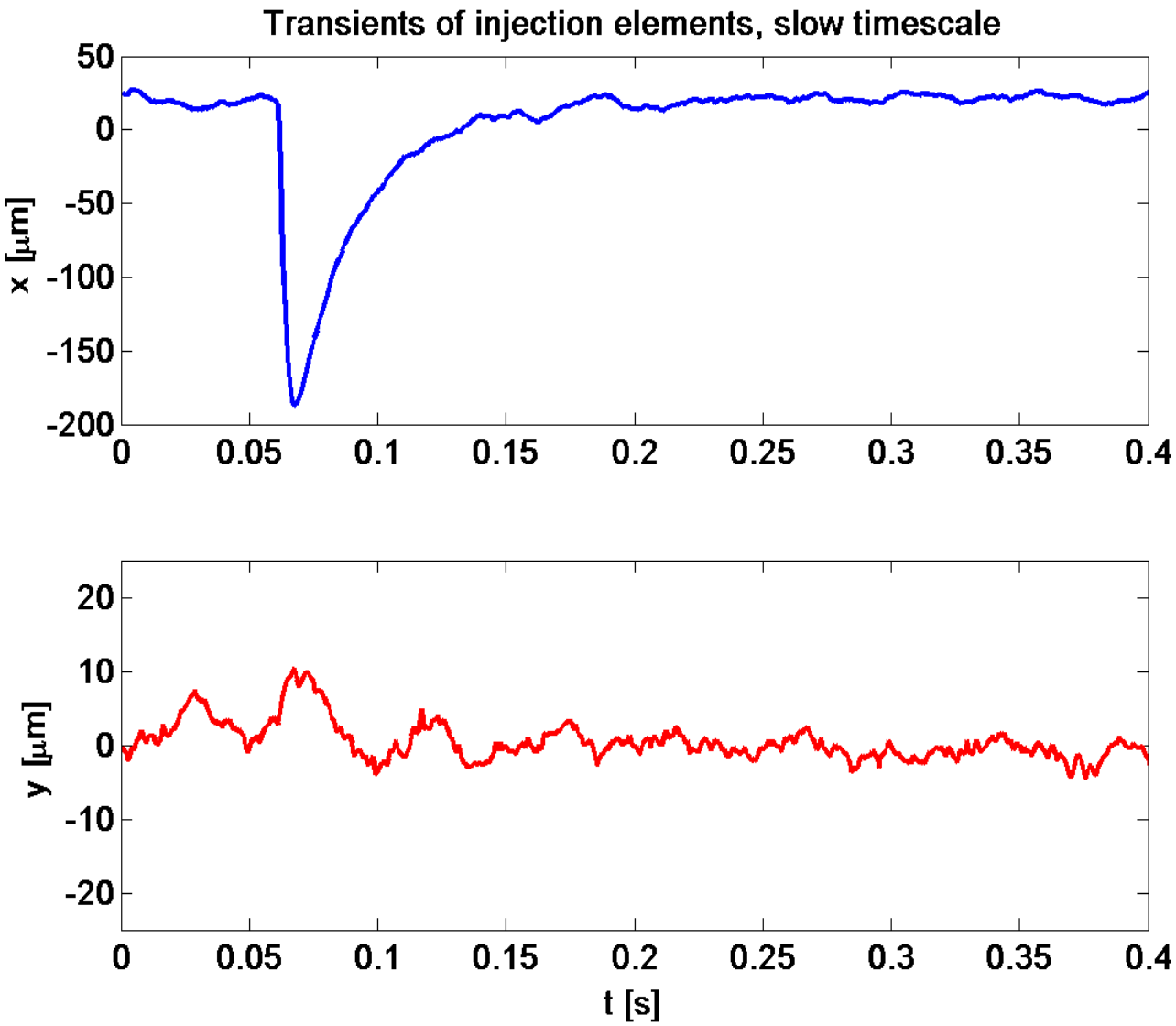


In terms of beamsize

~ 1.3 σ_x peak-to-peak

~ 4 σ_y peak-to-peak

Effect of the Septum



In terms of beamsize

~ 2/3 σ_x peak

< 1/3 σ_y peak

Effects of the inj. bumps and septa

Experimentalists

M. Martin (1.4), A.T. Young and E. Arenholz (4.0), David Kilcoyne (5.3.2), E. Gullikson (6.3.2), Eli Rotenberg (7.0), A. Scholl (7.3), J. Holton (8.3.1), J. Bozek (10.0), M. Marcus (10.3.2), T. Tyliszczak (11.0.2), K. Goldberg (12.0)

Three measurement dates → Participating Beamlines

December 7, 2003 → 5.3.2, 11.0

January 26, 2004 → 1.4, 4.0, 5.3.2, 7.0, 7.3 (PEEM), 8.3.1, 10.3.2, 10.0, 11.0.2

April 19, 2004 → 1.4, 4.0, 6.3.2, 11.0.2, 12.0

Meeting on February 13, 2004

Summarize the results of the December 7, 2003 and January 26, 2004 measurements

David Attwood, John Bozek, Erik Gullikson, James Holton, Zahid Hussain, David Kilcoyne, Mark Le Gros Dennis Lindle, Alastair MacDowell, Mathew Marcus, Howard Padmore, Andreas Scholl, Christoph Steier, Tony Warwick, Tony Young

Presentation to the UEC on March 2, 2004

Injection Tests for Top Off 19 April 2004

Three test conditions were run, with various beam lines looking at the effects:

Condition 1 normal operation.

Condition 2 injection bumps and septa pulsing every 30 seconds.

Condition 3 injection bumps only, every 30 seconds.

Best estimate is that the injection for top-off will be approximately every 30 seconds. The septum magnets are known to leak field and affect the position of the stored beam, if this problem is solved then condition 3 will best represent top-off operation.

No beam was actually injected during these tests. Observed variations in experiment count rates are due to transient distortions of the closed orbit.

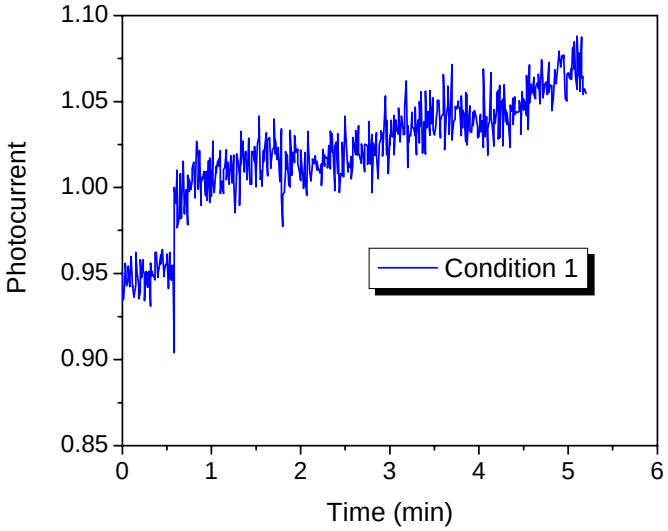
Beam lines 10.3.2 microXAS, saw no effects.

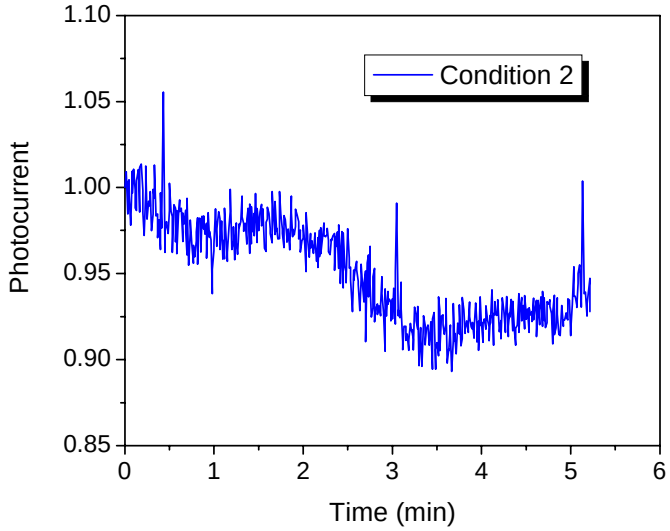
Beam lines 4.0 and 6.3.2 monitored the beam line flux and saw counting glitches under condition 2 that may be due to injection transients.

Beam line 1.4 (FT IR spectroscopy) saw definite glitches during instrument scanning under conditions 2 and 3.

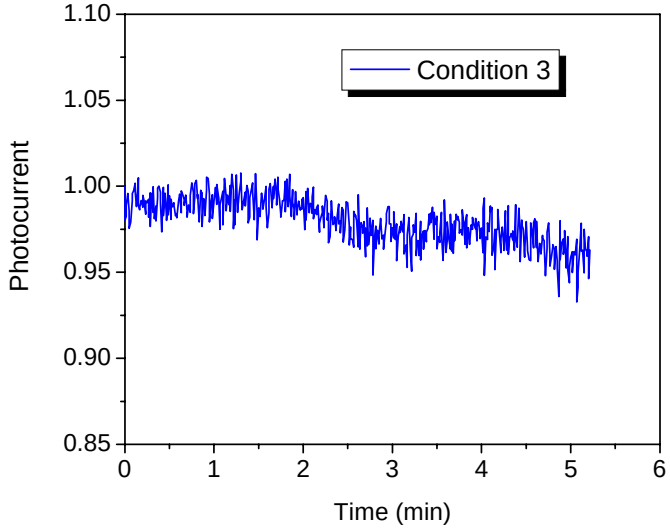
Beam line 11.0.2 (STXM) saw definite glitches during instrument scanning under condition 2.

Top off Mode Tests: BL 6.3.2



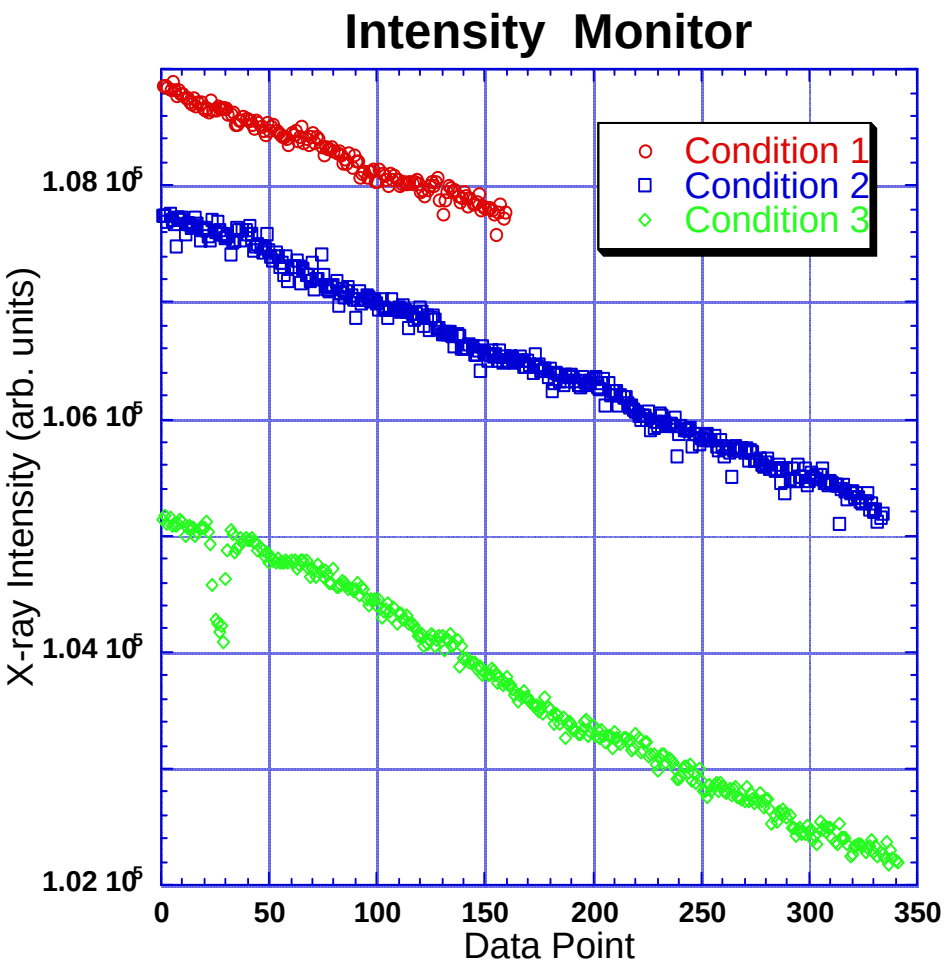


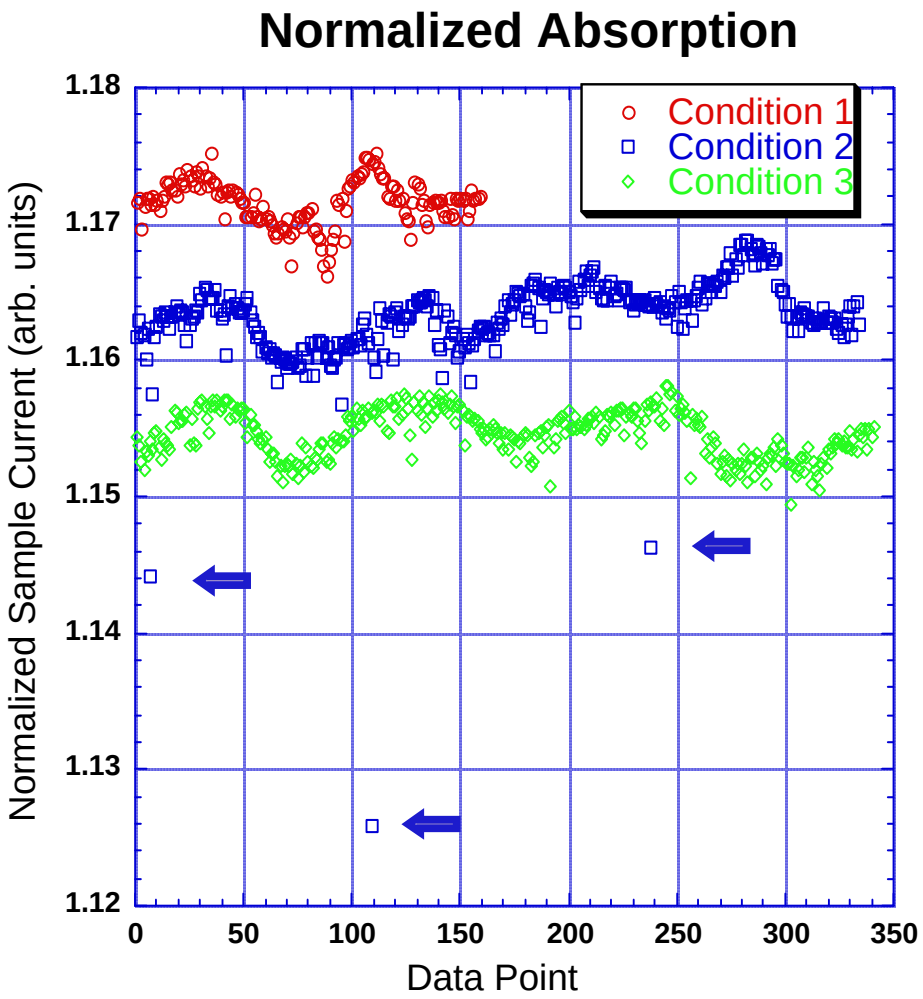
Signal measured after vertical slit offset in X by 160 microns from the center of the beam in the endstation. One point every 0.6 sec.



Erik Gullikson

Beamline 4.0.2





- **Absorption measured at Cu L_3 peak at 932 eV, 1 sec avg, every 3.75 sec**
- **Condition 2 Intensity is somewhat noisier**
- **Condition 2 Absorption shows several large deviations, indicative of a small photon energy shift, and consistent with an average injection period of 32.4 sec**
- **Actual injection time data is not available**

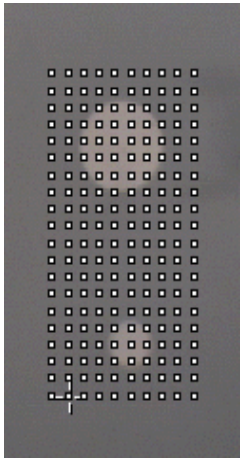
A.T. Young and E. Arenholz, BL4, ALS

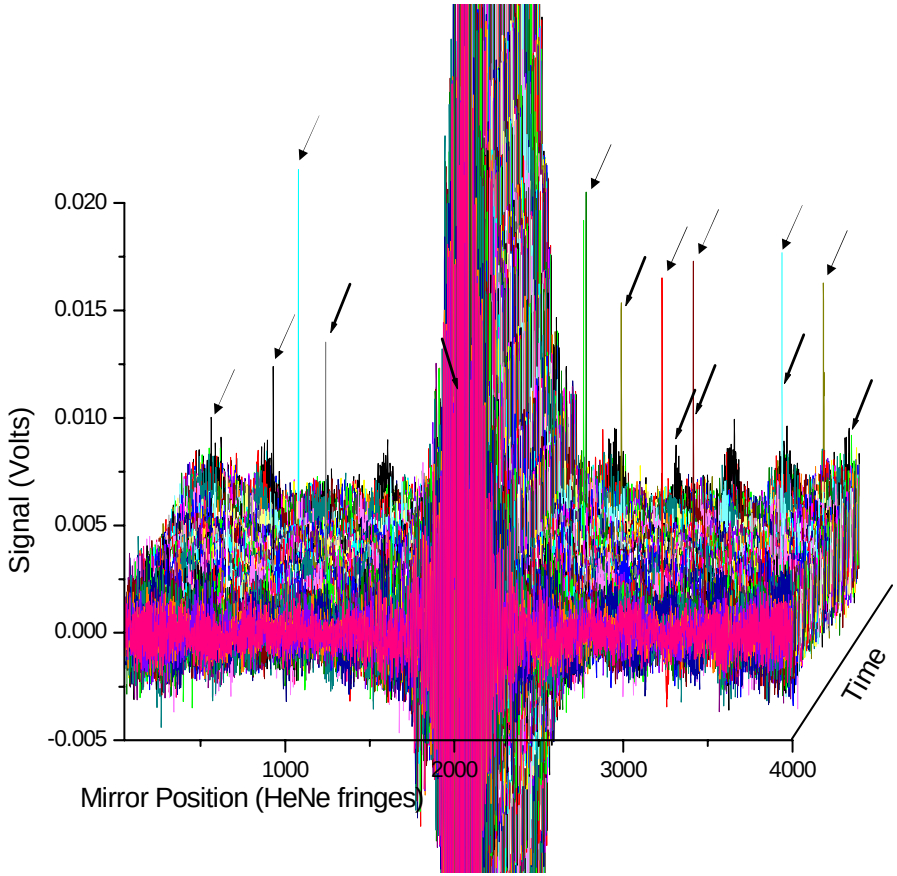
BL1.4.3

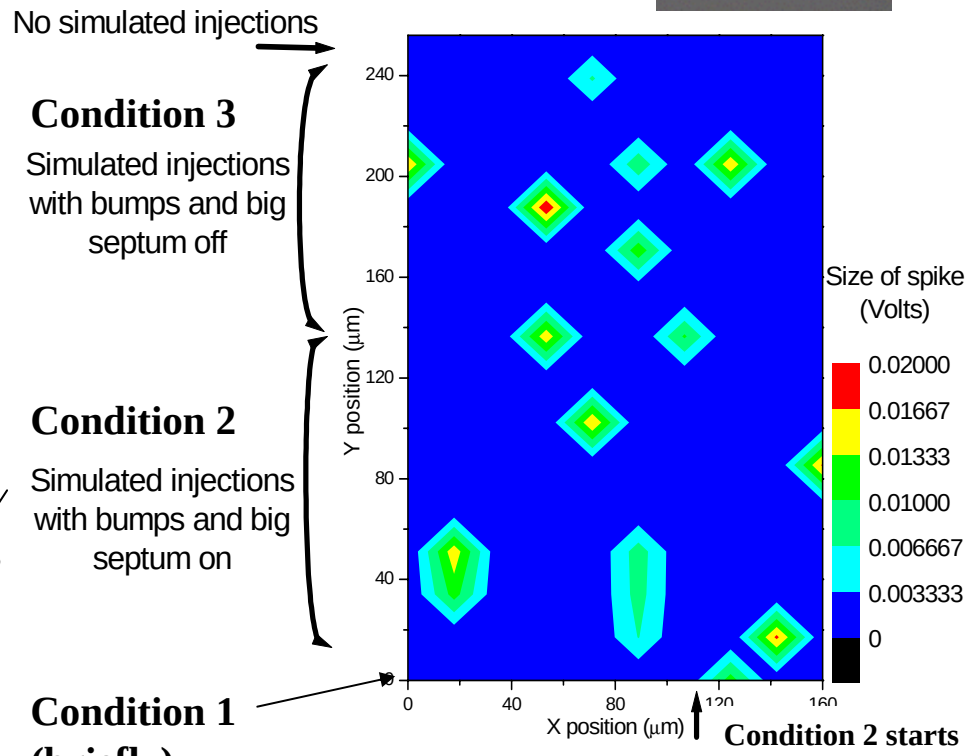
Summary:

- Simulated injections every ~30 seconds.
- I performed a “typical” mapping experiment, 32 averages (11.7 seconds) per point, + 7.5 seconds of dead time moving sample stage to next point. 160 total spectra during mapping test.

I see “spikes” in a number of scans throughout the test map:

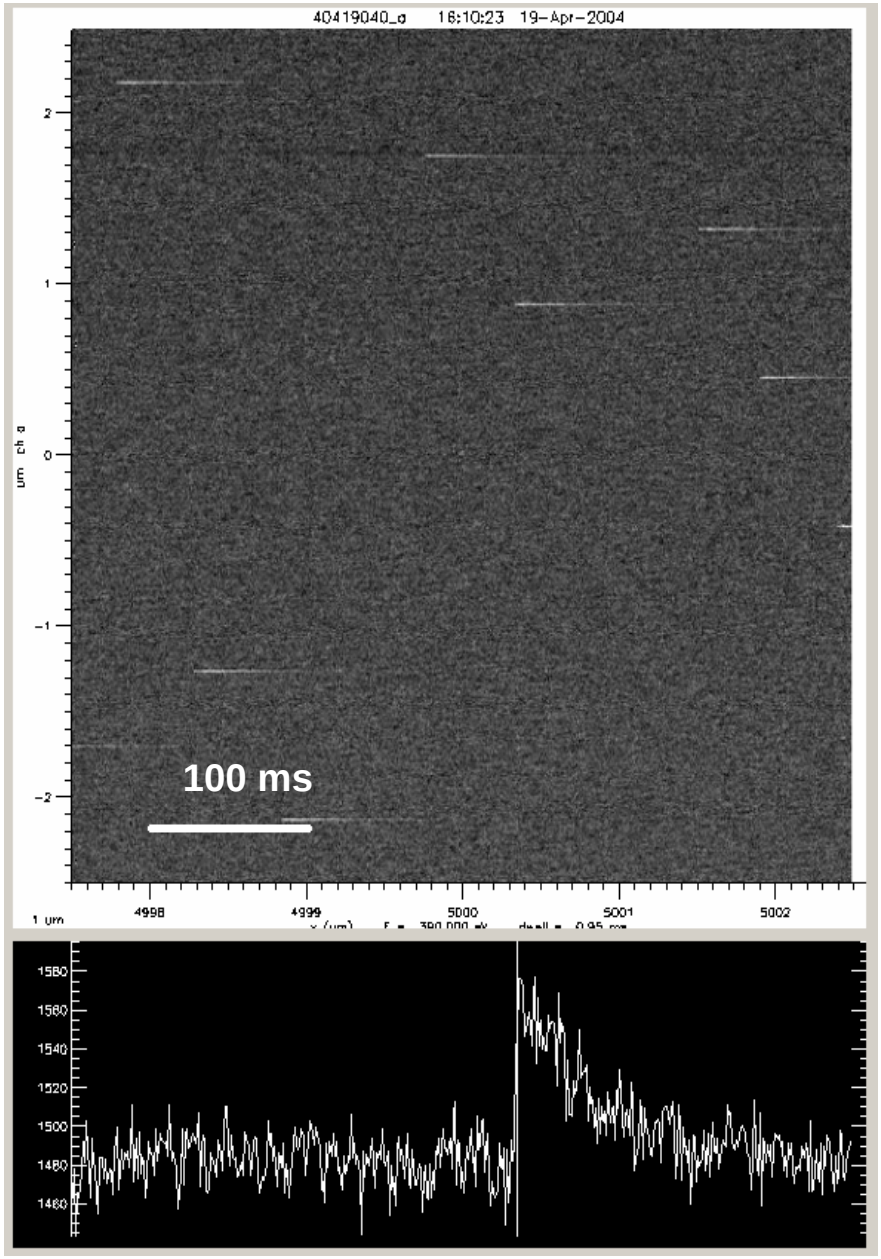






Michael C. Martin

BL11.0.2



During this test the sensitivity of the STXM 11.0.2 was much smaller then during the previous test (Dec 03).
Figure shows the influence of the injection (condition 2) - about 5 % of the signal for about 200 ms.
During condition 3 – the perturbation was within the noise level for 0.1, 0.2 and 1ms/pt image acquisition at 2 energies (1st and 3rd EPU harmonic).
Spectra acquisition at the exit slit (testing the beamline not STXM) did not show any significant perturbation.

Injection Tests for Top Off Dec/Jan 03/04

Seven test conditions were run, with various beam lines looking at the effects:
Condition 1 40mA no bumps or septa
Condition 2 bumps on and septa on, pulsing at 1Hz
Condition 3 feed-back H=off V=on
Condition 4 feed-back H=off V=off
Condition 5 400mA feed-back H=on V=off
Condition 6 400mA feed-back slow-orbit=off
Condition 7 bumps on and septa off

This is the original set of tests and the conclusions are similar to those drawn in April 04. The STXM tests were more sensitive on this occasion and definite glitches were apparent even with the septa turned off.

No beam was actually injected during these tests. Observed variations in experiment count rates are due to transient distortions of the closed orbit.

Beam lines 10.3.2 microXAS, 7.0 photoemission, 7.3.3 PEEM and 8.3.1 PX, saw no effects.

Beam lines 4.0 monitored the beam line flux and saw counting glitches under condition 2 that may be due to injection transients.

Beam line 1.4 (FT IR spectroscopy) saw definite glitches during instrument scanning under conditions 2 through 5.

Beam line 11.0.2 (STXM) saw definite glitches during instrument scanning under conditions 2 through 6, with greatly reduced transients under condition 7. Beam line 5.3.2 (STXM) saw the same, with variations depending on the feedback configuration.

Top-up tests: 10.3.2 Jan 04

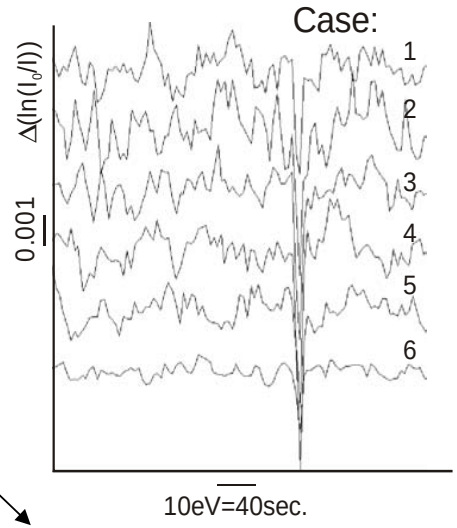
We cannot see any effect here

Experiments:

1. EXAFS on Ni foil starting at 9keV, transmission and fluorescence

2. Mapping on same Ni foil.

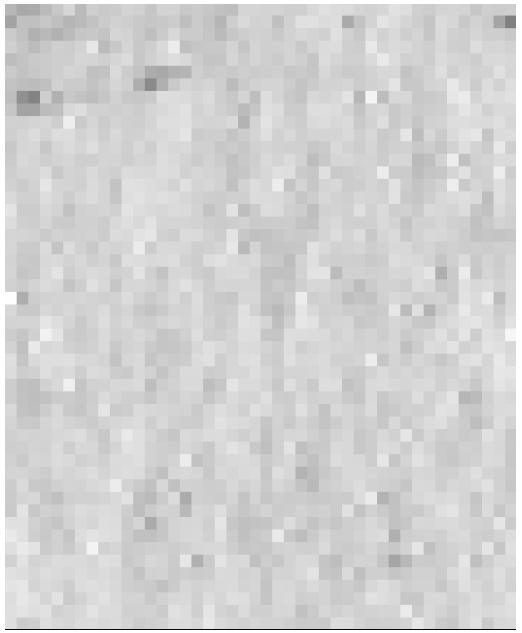
Executive summary: Nothing happened!



Cautions:

EXAFS: Count time was 4 sec/pt, so each point had the same number of blips, so even if blips affected the signal, we wouldn't see it. Real life: 30sec between blips; so a blip every 3-8 points.

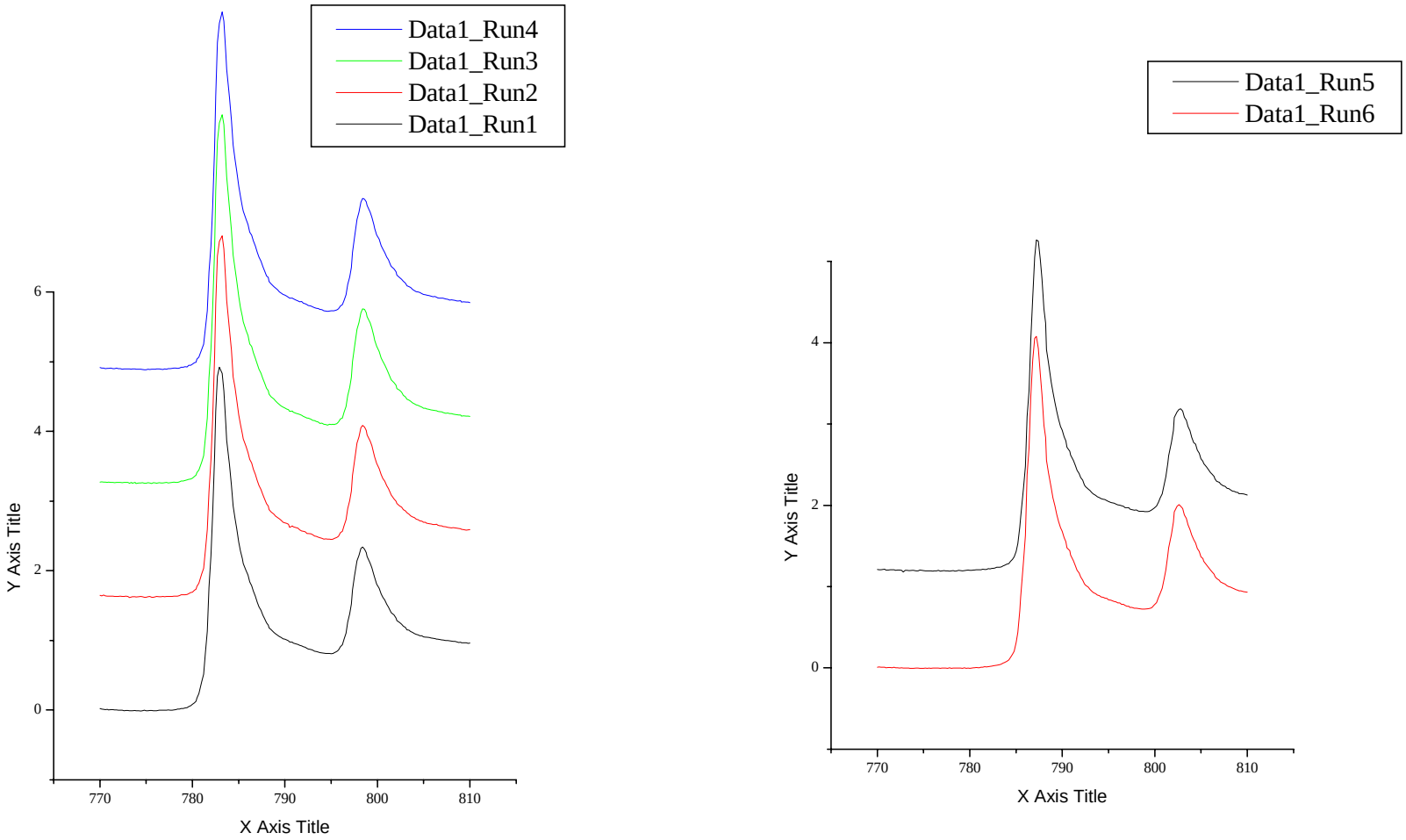
Mapping: Sample was inhomogeneous, which could have hidden the blips. Blips would have been 1-pixel excursions, several/line.



Top-up tests: 7.3.3 Jan 04

We cannot see any effect here

Typical Co NEXAFS spectra measured with PEEM-2 on 30x30 μm² area
Exposure time per point: 2s



No increase in noise is apparent.

Andreas Scholl

PX data in top-off mode, beam line 8.3

LSBL 709

We cannot see any effect here

case	exposure	R_{merge}	R_{anom}	I/sd	Patt	FOM	FOMDM	CC
1	1.00	4.3%	4.6%	29.0	6.77	0.274	0.746	0.4800
2	1.02	4.1%	4.6%	29.5	5.65	0.280	0.673	0.4958
3	1.04	4.3%	4.6%	27.7	6.10	0.267	0.729	0.4955
4	1.05	4.2%	4.6%	28.4	6.19	0.268	0.661	0.4704
5	0.10	4.8%	4.6%	26.3	5.97	0.270	0.751	0.4735
5a	0.90	4.2%	4.5%	29.2	5.71	0.278	0.671	0.4735
6	0.11	4.7%	4.6%	26.8	7.06	0.268	0.665	0.5036
6a	0.93	4.2%	4.5%	29.6	5.72	0.284	0.701	0.4982

All data sets had the same dose: $2x10^6$ Ph/um^2

the “a” data sets used an Al attenuator to normalize the exposure time

Exposure: the shutter-open time used for 100 images

Rmerge: standard error of equivalent diffraction spot intensities

Ranom: difference between Friedel mates

I/sd: signal-to-noise ration

Patt: height/sigma for non-origin Patterson peak

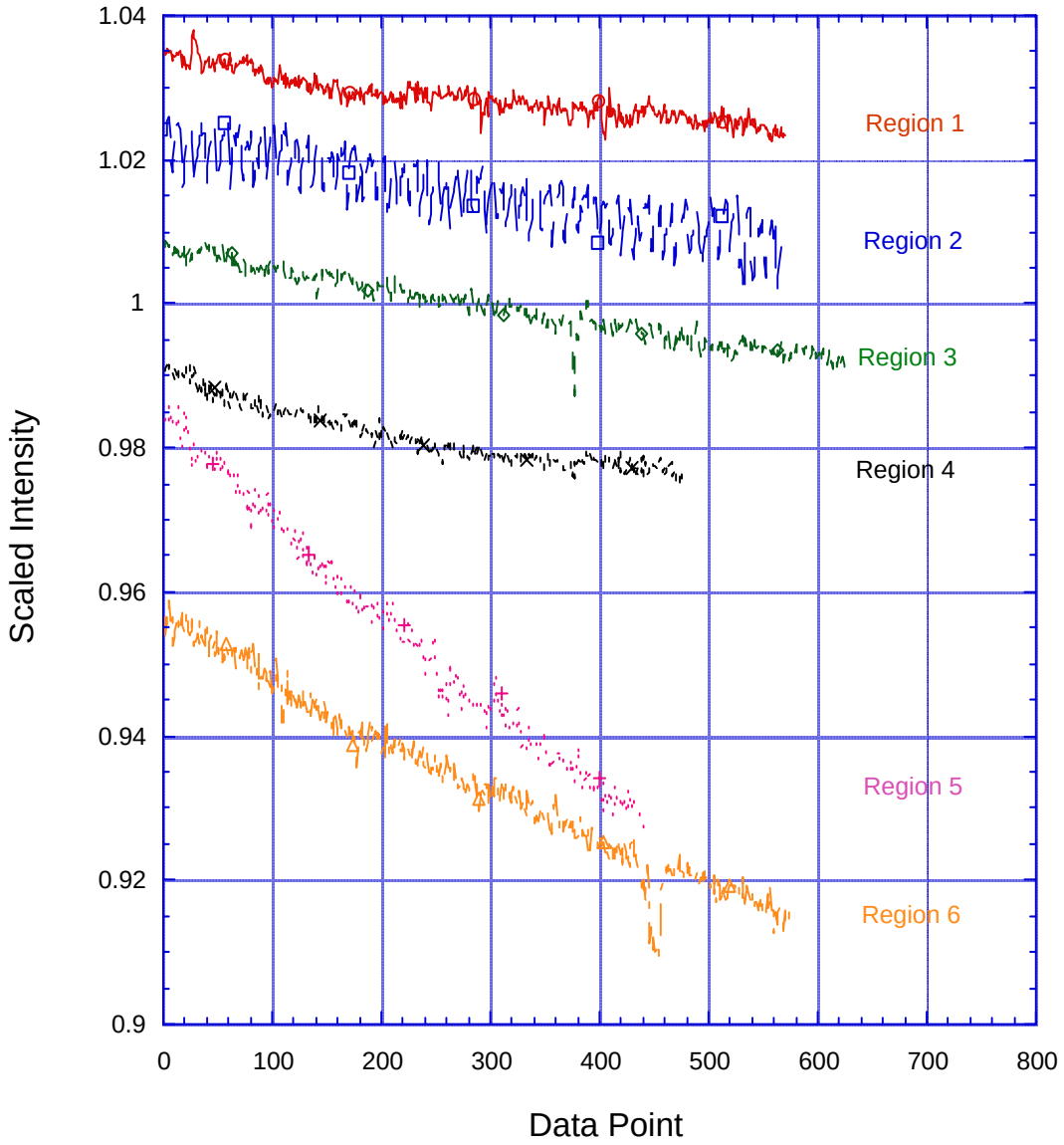
FOM: estimated cosine of phase error

FOMDM: FOM after density modification

CC: correlation coefficient of experimental map to model

James Holton

Top Off Mode Injection Test: BL 4.0 1/26/04



'condition 2' = septum-on we can see intensity fluctuations

Intensity of the x-rays was determined by measuring the photo-current from a gold mesh

Each data point was integrated for 1 second using a picoammeter and a V/F converter

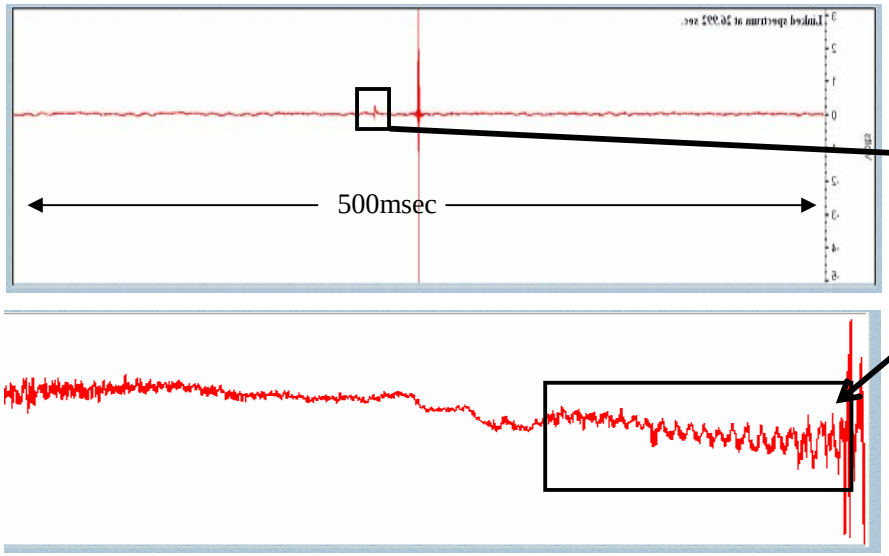
Each region (condition) was scaled to unity and offset for clarity

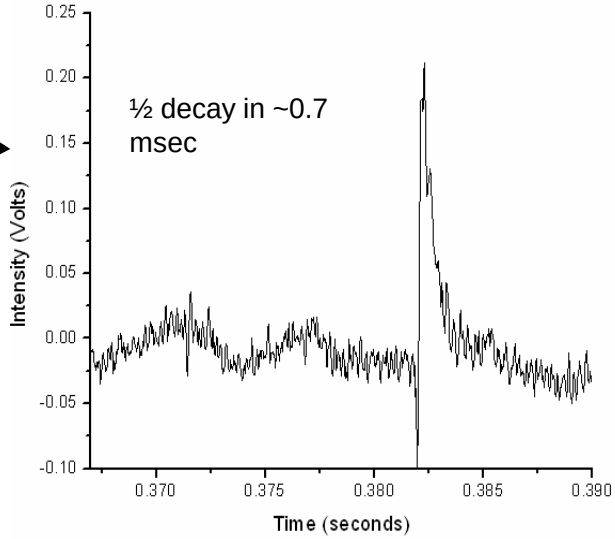
Tony Young and Elke Arenholz

Top-Off Tests, BL1.4.3 - Jan 26, 2004

Summary:

In conditions 2-5 (injection septum and/or bumps on) we observed brief signal glitches in measured interferograms. Not seen in conditions 1 or 6 (no injection).





- The typical user averages many spectra, so this will "wash out" into worse Signal to Noise.

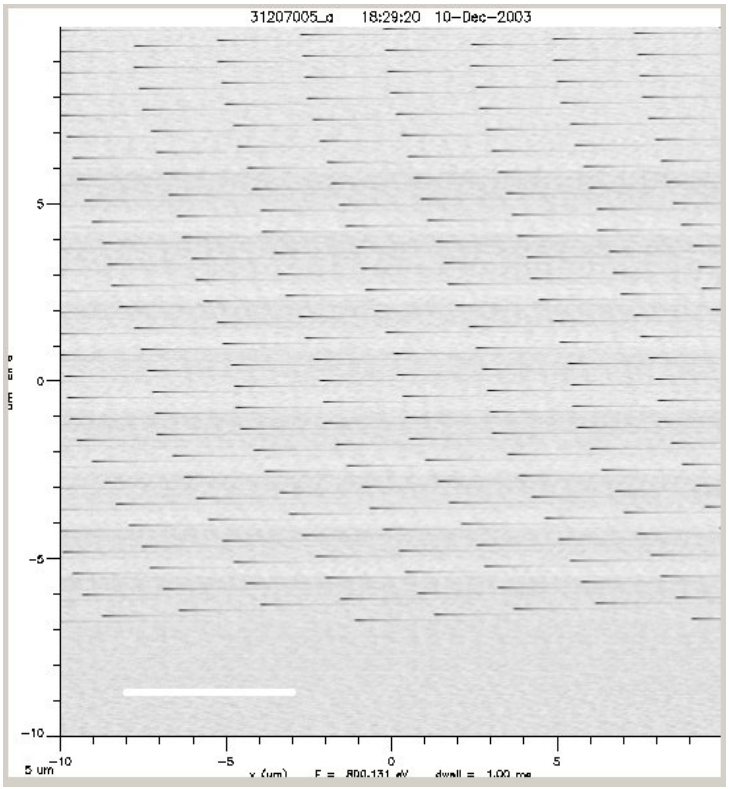
- Or we should look for a way to have the software/hardware reject scans when the injection bumps are on.

Condition	Current	S/N
1	40	1470
2	38.3	1243
3	37.6	956
4	36.9	1108
5	387	3467
6	370	3662

Michael C. Martin

"Injection" test 7 Dec 2003

Recorded STXM images



Condition 6 feed-back slow-orbit=off

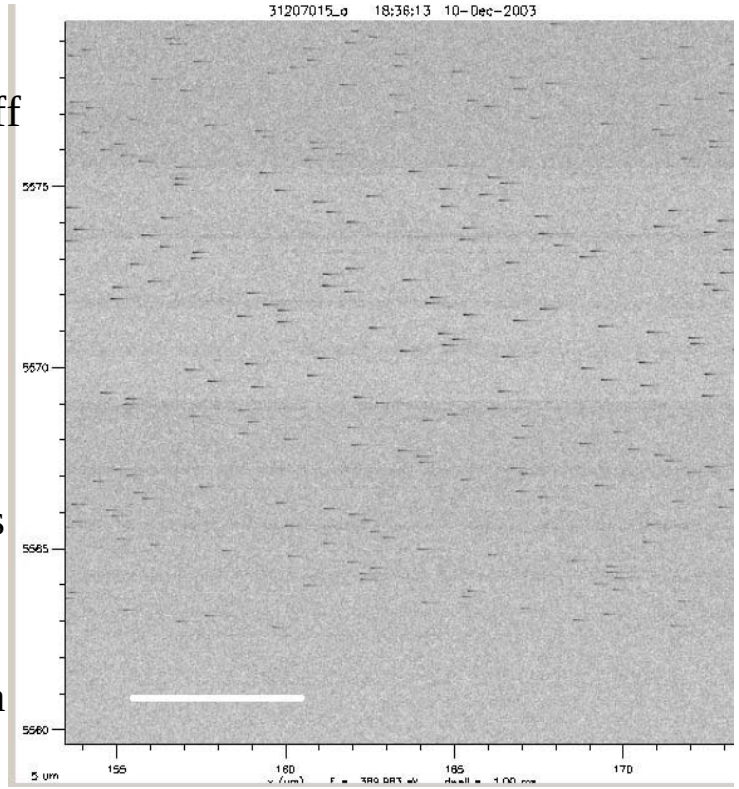
Condition 5 feed-back H=on V=off

Condition 4 feed-back H=off V=off

Condition 3 feed-back H=off V=on

Condition 2 bumps and septa on

Condition 1 No bumps or septa



STXM 11.0.2

Undulator, entrance slit-less beam line designed with in-sensitivity to vertical beam motion, sensitive to horizontal beam motion.

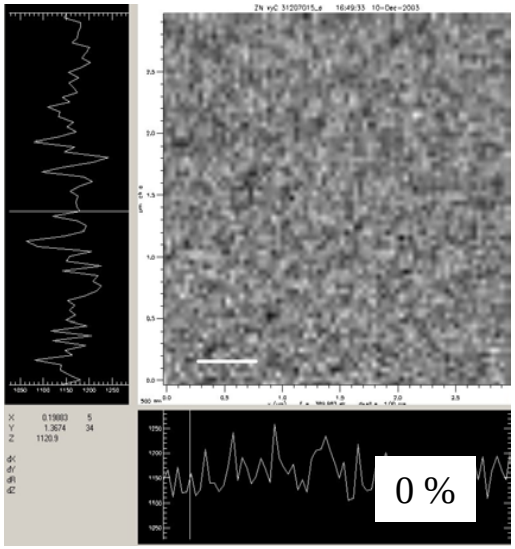
Horizontal scale is 500 ms

STXM 5.3.2

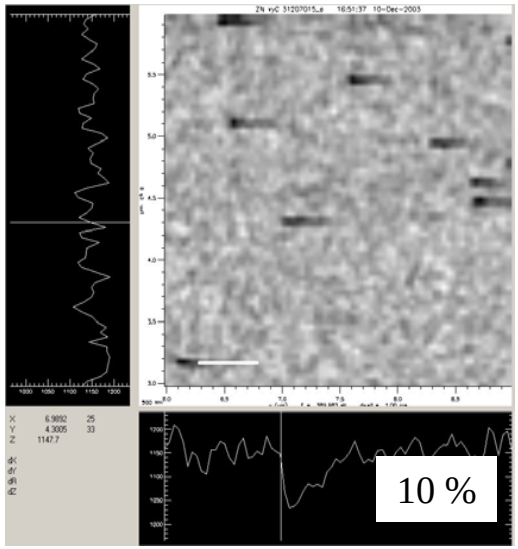
Bend magnet, collecting part of the fan, sensitive to vertical beam motion.

“Injection” tests 7Dec 2003 STXM 5.3.2

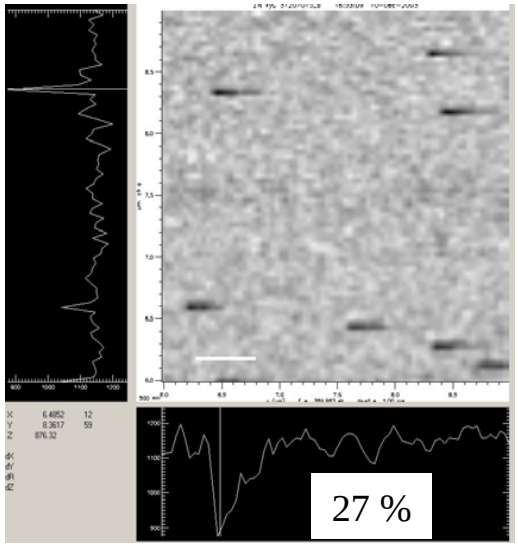
Condition 1
No bumps or septa



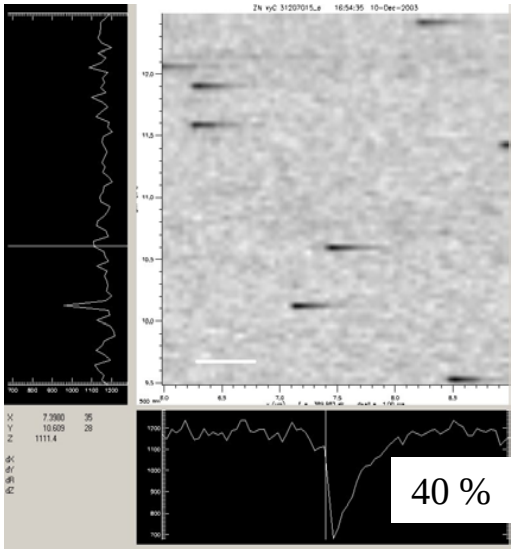
Condition 2 bumps
and septa on



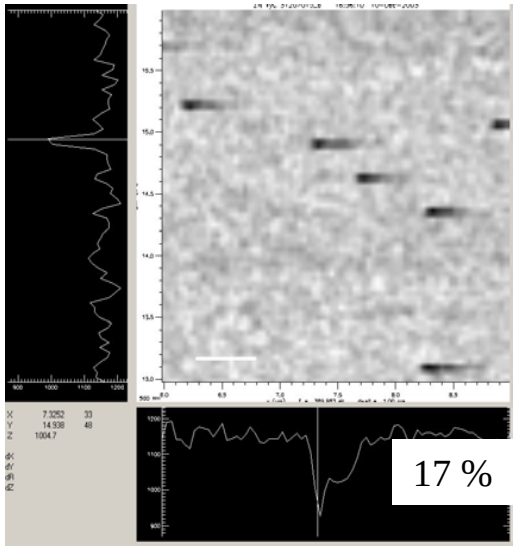
Condition 3 feed-
back H=off V=on



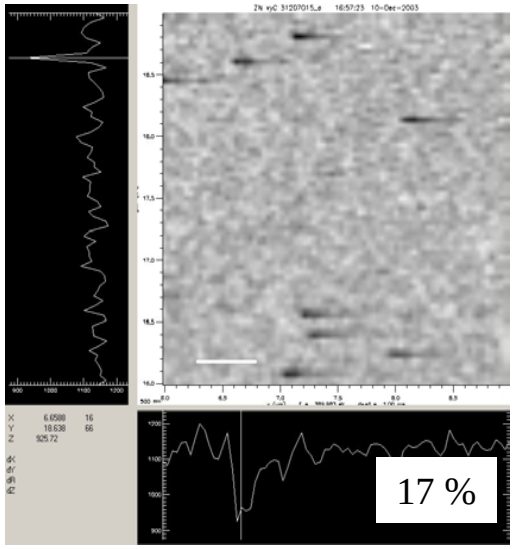
Condition 4 feed-
back H=off V=off



Condition 5 feed-
back H=on V=off



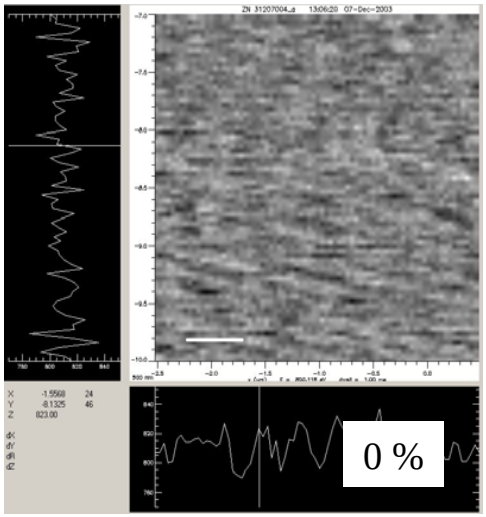
Condition 6 feed-
back slow-orbit=off



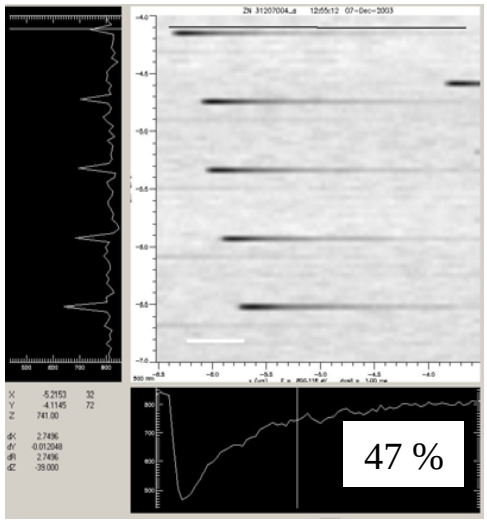
Horizontal scale is 75 ms

“Injection” tests 7Dec 2003 STXM 11.0.2 zoom-in

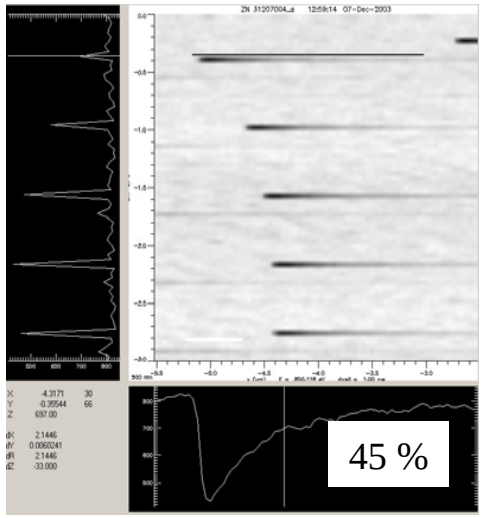
Condition 1
No bumps or septa



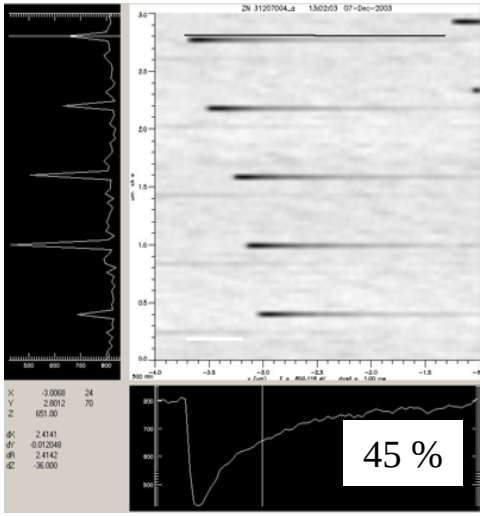
Condition 2 bumps
and septa on



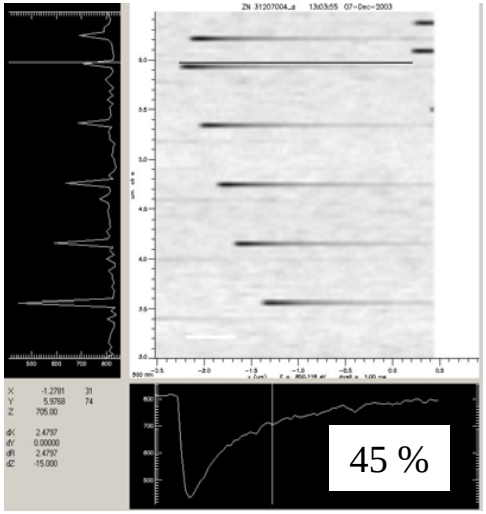
Condition 3 feed-
back H=off V=on



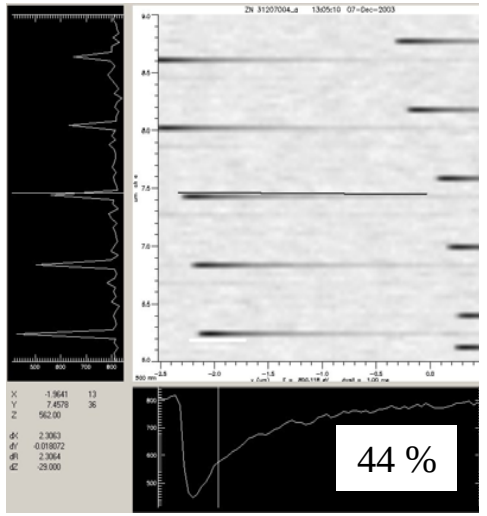
Condition 4 feed-
back H=off V=off



Condition 5 feed-
back H=on V=off

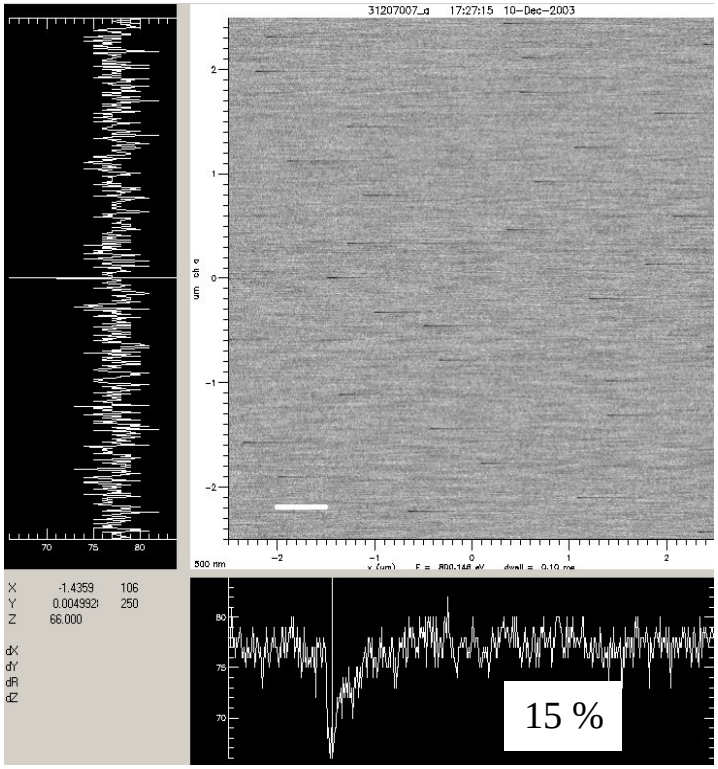


Condition 6 feed-
back slow-orbit=off



Horizontal scale is 75 ms

Recorded image



Horizontal scale is 60 ms

Summary

Summary

- Most experiments did not see the injection transients
- The most sensitive experimental techniques were microscopes with short integration times – in particular STXM (5.3.2 and 11.0.2), IR (1.4.3)
  - For these techniques gating may be a good option and seems not to be too difficult
- Beamline 4.0 also sensitive to the Septum
  - Planned improvements in the Septum should be sufficient

Other issues addressed

- Those requiring gating would like “single shot” injection (i.e. no burst mode)
- Users not very sensitive to bunch-to-bunch current variations
- Users would like to incorporate injection bunch cleaning in the project in order to have cleaner camshaft and 2-bunch top-off operation